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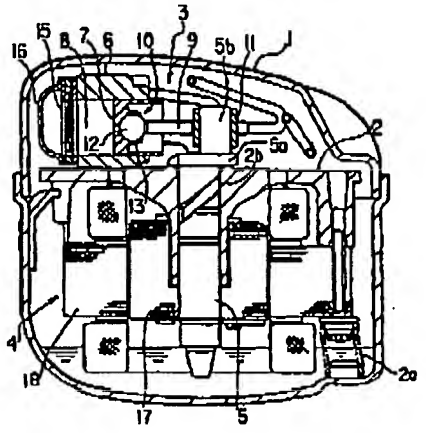
[54] 发明名称 往复式密封型电动压缩机

[57] 摘要

一种往复式密封型电动压缩机，使连杆(9)从与转轴(5)一体的曲柄销(5b)延伸、通过球窝接头机构部(10)使连杆(9)与收容在气缸(8)的活塞(7)连接，所述球窝接头机构部(10)由一体设在连杆(9)的球(12)与设在活塞(7)上、滑动自如地抱住球(12)的球轴承(13)组成，以压缩对象定为制冷剂即异丁烷(R600a)，并将球窝接头机构部(10)的平均速度V与压缩行程时作用于球窝部(10)的荷载F的关系设定为 $V \times F < 200N \cdot m/s$。采用本发明，不仅对防止臭氧层破坏有效，而且能够适应于使用较少影响到地球温室化的制冷剂即异丁烷(R600a)的制冷循环，并提高可靠性。



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Reciprocating Hermetic Electric Compressor

Technical Field

The invention relates to a reciprocating hermetic electric compressor for refrigerating cycle, and which uses the isobutane (R600a) that is a natural refrigerant as the fluid for compression.

Background of the Art

For example, in a refrigerator and the like, a reciprocating hermetic electric compressor is widely used as a compressor which constitutes refrigerating cycle. Furthermore, in such compressor, the ball-and-socket joint mechanism section is one of the means connecting the crank pin integrally disposed on a main shaft with the piston contained in a cylinder.

In ball-and-socket joint mechanism section, the crank pin freely rotationally inserted in a main shaft is connected with an end section of a connecting rod, and the other end section of a connecting rod extends inside a piston. A ball is disposed integrally on the other end section of the connecting rod, and is enclosed by the ball shaft of the piston, and freely slide.

The main shaft is rotationally driven, the connecting rod is swigged centered the ball-and-socket joint mechanism section along with the eccentric rotation movement of the crank pin. Thus, a piston moves reciprocatingly in the cylinder, and inhalation and discharging of a refrigerant is repeatedly conducted.

However, R134a (1,1,1,2-tetrafluoroethane) that is HFC (Carbon Hydrogen Fluoride) refrigerant is generally used as the refrigerant for the refrigerator. By using R134a, concern of the ozone layer depletion which is the fault of the refrigerant (R12) is canceled, and it is very effective in respect of earth environmental protection.

As refrigerant, the refrigerant having the lower coefficient of greenhouse effect of the earth other than ozone depletion coefficient is required. In R134a, the ozone depletion coefficient is "0", while greenhouse effect coefficient is certain value. Therefore, as long as all refrigerating cycle device use R134a, there is a possibility that will affect to the global warming in the near future.

On the other hand, as the refrigerant having lower ozone depletion coefficient

and lower greenhouse effect coefficient, the isobutane (R600a) is known. By using this kind of refrigerant, most prevention of ozone layer depletion and global warming can be reconciled, and it is very ideal.

However, the present condition is in during the development of the refrigerating cycle component part which is adapted for R134a, the development about the component part which is adapted for an isobutane (R600a) refrigerant has not started. Thus, the inventor is paying attention to the compressor in which effect appears most notably by changing refrigerant.

Summary of Invention

One object of the invention is to provide a reciprocating hermetic electric compressor which is not only effective in ozone-layer-depletion prevention but global warming, and has improved reliability.

In order to satisfy the above-mentioned purpose, reciprocating hermetic electric compressor of the invention extends a connecting rod from the crank pin of a main shaft; the connecting rod is connected with the piston held in a cylinder through the ball-and-socket joint mechanism section; the ball-and-socket joint mechanism section is consisted of a ball disposed integrally on the end section of the connecting rod and a ball bearing which is disposed on a piston and freely slidingly encloses a ball; when the fluid for compression is as a refrigerant: isobutane (R600a), the average speed V of the ball-and-socket joint mechanism section, and relation with the load F which acts on the ball-and-socket joint mechanism section at the time of a compression stroke is set as: $V \times F < 200N \cdot m/s$.

Furthermore, the diameter d of the ball constituting the ball-and-socket joint mechanism section was set below to 14.5 mm.

In rocking movement of the connecting rod accompanying eccentric rotation of a crank pin, the rocking angle of a connecting rod was set as 54 degrees or less.

The rotational speed of the main shaft was set as below to 105 (rps).

Furthermore, the ball bearing is treated with nitriding treatment and phosphoric-acid manganese treatment or one of the above treatments.

As a material of a ball, the high-carbon-chromium steel materials which contain chromium (Cr) 0.5 to 2.0% were adopted.

A buffer ring which is consists of thermoplastics material, such as PTFE and

PFA, is interposed between the ball and the ball bearing.

By adopting a means to solve the above technical problem, it becomes the compressor suited for refrigerant being isobutane (R600a), to improve reliability.

Brief Description of Drawings

Figure 1 is a front view of longitudinal section of the reciprocating hermetic electric compressor of one embodiment of the invention.
Figure 2 is a view illustrating a part of the operation of the compression mechanism of one embodiment of the invention.
Figure 3 is a view showing the relation of the F×V value of the ball-and-socket joint mechanism section vs. the wear loss of the ball bearing of one embodiment of the invention.

Embodiment of the Invention

Hereafter, the embodiment of the invention is explained based on the drawings.

Figure 1 shows the front view of the longitudinal section of the reciprocating hermetic electric compressor which constitutes the refrigerating cycle of a refrigerator.

As a refrigerating cycle of a refrigerator, it has the condenser, the expansion equipment and the evaporator other than the above-mentioned compressor, and these equipments are communicated by refrigerant pipes to constitute the refrigerating cycle loop.

As a refrigerant used for such refrigerating cycle, the isobutane (R600a) which is a natural refrigerant is adopted, and it is characterized by having the reciprocating hermetic electric compressor mentioned later as a compressor which is most adapted for this refrigerant.

In such reciprocating hermetic electric compressor, in Figure 1, 1 represents a vertical sealing case. On the middle section inside of the case 1, frame 2 is supported elastically by spring 2a. A compression mechanism section 3 is fixed on the upper side of the frame 2, and a motor 4 is disposed on the lower side.

The compression mechanism section 3 uses the so-called reciprocating hermetic compressor. In addition, it explains that a hole 2b for pivotally support is disposed along the center section of frame 2, in which the rotation shaft 5 is

inserted free rotationally.

Flange 5a is provided on the upper end section of the rotation shaft 5, which is disposed freely slidablely above the frame 2. A crank pin 5b is connected with the upper section of the flange 5a, which has the center axis which defines eccentricity to the center axis of rotation shaft 5.

Thus, when the rotation shaft 5 is driven, flange 5a will rotate in the state of a slide contact on the upper surface the frame 2, and the crank pin 5b will eccentrically rotate around the center of rotation shaft 5.

Furthermore, the compression mechanism section 3 is provided on the upper surface of the frame 2, and is equipped with the cylinder 6 which turned shaft orientations horizontally. The interior of the cylinder 6 serves as the cylinder chamber 8 in which a piston 7 is contained freely reciprocatingly.

The end of a connecting rod 9 is connected with the piston 7 through the ball-and-socket joint mechanism section 10. The large end 11 is disposed on the other end of the connecting rod 9, which is freely inserted the crank pin 5b.

The ball-and-socket joint mechanism section 10 is formed with a ball 12 in the end of the connecting rod 9. The ball bearing 13 is formed inside the piston 7. The ball 12 is enclosed by ball bearing 13 and freely rotates therein.

By this, with eccentric rotation of crank pin 5b, a connecting rod 9 can form rocking movement supporting by the ball-and-socket joint mechanism section 10 to cause a piston 7 to reciprocate in a cylinder 6.

On the other hand, the opening end of a cylinder 6 is sealed by the valve mechanism 15, and covered by the valve cover 16. Although not illustrated in a detail, the partition section which bisects the interior is disposed in the valve cover 16, and, one space forms an absorption room, another space serves as an exhaust room.

The valve mechanism 15 is provided with valve plate having absorption opening and an exhaust opening, and each absorption opening and an exhaust opening is opened and closed by an intake valve and the discharge valve. And the absorption opening opposes to the absorption room, and the exhaust opening opposes to the exhaust room.

Thus, to the constituted compression mechanism section 3, the motor section 4 is equipped with the peripheral surface of rotor 17 attached in the part which projects caudad from the frame 2 of the above-mentioned rotation shaft 5, and this Rota 17, and the inner skin which consists a narrow gap, and consists of a

stator 18 by which vertical installation immobilization is carried out with a proper means from the above-mentioned frame 2.

Next, compression operation of the reciprocating hermetic electric compressor and the refrigerating cycle operation accompanying it are explained.

If it energizes in the motor section 4 and the rotation drive of the rotation shaft 5 is carried out, crank pin 5b will carry out eccentric rotation at one. According to this eccentric rotation, a piston 7 carries out both-way fate of the inside of the cylinder room 8 to a connecting rod 9 through the ball-and-socket joint mechanism section 10.

In the sealing case 1, the low voltage refrigerant gas, i.e., isobutane (R600a) gas, which is evaporated by the evaporator, is introduced. This gas is led to the absorption room in a valve cover 16, and is further inhaled by the cylinder room 8 of a cylinder 6 with migration (forward movement) of a piston 7.

Isobutane gas (R600a) is compressed because a piston 7 moves backward (backward action). When the piston 7 moves to the so-called dead point, a discharge valve will be opened, and the compressed and high pressureized isobutane gas at the cylinder room 8 will be discharged by the exhaust room of a valve cover 16.

Furthermore, this high pressure gas is drawn from the sealing case 1 through the discharge tube within a case to an external refrigerant pipe, and is led to an above-mentioned refrigerating cycle. From the place which the rotation shaft 5 is continuing and rotating, a piston 7 carries out reciprocating movement and an above-mentioned refrigerating cycle is repeated.

Figure 2 is the top view of the outline which made the cross section a part of compression mechanism section 3.

Especially, the relation between eccentric rotation of the crank pin 5b, rocking movement of the connecting rod 9 accompanying it, and the ball-and-socket joint mechanism section 10 and the piston 7 is explained.

Crank pin 5b carries out eccentric rotation with rotation of the rotation shaft 5, and the center of the crank pin Oa draws the circular rotation locus A1 which makes eccentricity a radius of gyration. The connecting rod 9 rocks in a predetermined rocking angle a, and in the ball-and-socket joint mechanism section 10, a ball 12 and the ball bearing 13 slide with respect to each other.

When the isobutane (R600a) gas which is a refrigerant gas introduced into the cylinder room 8 is compressed, a load is applied to the end surface of the

piston 7, and the force acts on the ball-and-socket joint mechanism section 10 through a piston 7.

Generally, as evaluation to the ball-and-socket joint mechanism section 10, although the product of the planar pressure (P) concerning the ball-and-socket joint mechanism section 10 and the sliding rate (V) of the ball-and-socket joint mechanism section 10 is raised, let the product of the mean velocity (V) at the time of the maximum load (F) and sliding of a ball 12 be an index here.

The equation which asks for the product of maximum load F and mean velocity V is as follows:
$F=(p/4) \times (D^2) \times (Pd-Ps)$
$V=p \times d \times (a/360) \times f$

where D represents the diameter of the piston 7, Pd represents discharge pressure, Ps represents suction pressure, d represents the diameter of the ball 12, a represents the rocking angle of the connecting rod 9, f represents the rotation speed of the rotation shaft 5.

Figure 3 shows the relation of F x V value and the abrasion loss of the ball bearing 13 in the ball-and-socket joint mechanism section 10.

When F x V value is below 200 N · m/s, it is a good state that abrasion loss is low. When F x V value is above 200 N · m/s, there is a trend of increasing the abrasion loss.

If working pressure of an isobutane (R600a) is a consideration condition, the discharge pressure is assumed as a maximum of 1 (MPa), suction pressure is at least 0.05 (MPa).

In this case, in order to satisfy F x V<200 N · m/s, it is better that the diameter of ball 12 is below 14.5 mm, the rocking angle is below 54 degree, and the rotation speed of the rotation shaft is below 105 rps.

Furthermore, in order to improve the abrasion resistance of the ball-and-socket joint mechanism section 10, it is an effective means to perform nitriding treatment or phosphoric-acid manganese treatment to the ball bearing 13 which is on the support side of the ball-and-socket joint mechanism section 10, or one of these treatments.

Moreover, it is also effective to use the high-carbon-chromium steel materials containing 0.2-2.0% chromium as a material of the ball 12 integrally disposed in the end of a connecting rod 9.

Thus, the ball bearing 13 receives a ball 12 by riveting (plastic deformation) process as the characteristic in the ball-and-socket joint mechanism section 10. Then, the sliding in the ball-and-socket joint mechanism section 10 is extremely carried out smoothly by interposing the buffering 20 of the shape of a ring which becomes a riveting part from thermoplastics material, such as PTEF and PFA, as shock absorbing material.

In addition, a refrigerant (R600a) is hydrocarbons, and also may be an inflammable refrigerant. If the pressure of the refrigerating cycle is smaller than atmospheric pressure, and it becomes the conditions which gas leaks from a refrigerating cycle under a certain situation, air will be inhaled in a refrigerating cycle.

On the other hand, when a detailed blemish is in the coil section of the stator 18 which constitutes the motor section 4, it discharges from a blemish and an arc occurs. Consequently, fear of combustion or explosion has the isobutane (R600a) which is an inflammable refrigerant within a refrigerating cycle.

In addition, there are a distributed winding and a concentrated winding as a means of a coil against stator 18 iron core. In response to stress, a blemish tends to generate in the above-mentioned distributed winding. For concentrated winding, the coil does not receive stress, a blemish does not occur.

Then, in the case of a distributed winding, the blemish in response to stress is repaired by fixing the electrical insulator in the coil after motor completion. In particular, paint is applied to the coil as insulator after winding, and then is subject to heat fixing or fixing under normal temperature.

Therefore, even if it is a distributed winding, the risk of combustion or explosion is canceled in the refrigerating cycle using an inflammable refrigerant isobutane (R600a). Since in the case of a concentrated winding a coil does not receive stress and a blemish does not occur, it uses as it is.

Furthermore, although in the compression mechanism section 3 of the reciprocating hermetic electric compressor shown in Figure 1, a cylinder 6 is explained as a separate device (one cylinder), it is not limited to this. The compression mechanism section may be equipped with a pair of cylinder (two cylinders) symmetrically the right-and-left both sides of a rotation shaft 5, and all the above-mentioned limited requirements are applied as it is.

As explained above, according to this invention, it can apply to the refrigerating cycle using a refrigerant, i.e., isobutane with little effect in global warming (R600a). It is not only effective in ozone layer depletion prevention, but the

effectiveness that improvement in dependability can be aimed at is done so.

Claims

1. A reciprocating hermetic electric compressor which extends a connecting rod from the crank pin of a main shaft, the connecting rod being connected with the piston held in a cylinder through a ball-and-socket joint mechanism section, characterized in that the ball-and-socket joint mechanism section is consisted of a ball disposed integrally on the end section of the connecting rod and a ball bearing which is disposed on a piston and freely slidingly encloses a ball; when the fluid for compression is as a refrigerant: isobutane (R600a), the average speed V of the ball-and-socket joint mechanism section, and relation with the load F which acts on the ball-and-socket joint mechanism section at the time of a compression stroke is set as: $V \times F < 200N \cdot m/s$.

2. The reciprocating hermetic electric compressor according to claim 1, characterized in that the diameter d of the ball which constitutes the ball-and-socket joint mechanism section is below 14.5 mm.

3. The reciprocating hermetic electric compressor according to claim 1, characterized in that the rocking angle of the connecting rod is set as 54 degrees or less in rocking movement of the connecting rod accompanying eccentric rotation of the crank pin.

4. The reciprocating hermetic electric compressor according to claim 1, characterized in that the rotational speed of the main shaft is set to below 105 rps.

5. The reciprocating hermetic electric compressor according to claim 1, characterized in that the ball bearing which constitutes the ball-and-socket joint mechanism section is processed by nitriding treatment and phosphoric-acid manganese processing, or one of these two treatments.

6. The reciprocating hermetic electric compressor according to claim 1, characterized in that the material of the ball which constitutes the ball-and-socket joint mechanism section is the high-carbon-chromium steel materials which contain chromium (Cr) 0.5 to 2.0%.

7. The reciprocating hermetic electric compressor according to claim 1, characterized in that buffering ring which consists of thermoplastics material, such as PTFE and PFA, is interposed between the balls and ball bearings which constitute the ball-and-socket joint mechanism section.

Abstract

A reciprocating hermetic electric compressor which extends a connecting rod from the crank pin of a main shaft, the connecting rod is connected with the piston held in a cylinder through the ball-and-socket joint mechanism section, the ball-and-socket joint mechanism section is consisted of a ball disposed integrally on the end section of the connecting rod and a ball bearing which is disposed on a piston and freely slidingly encloses a ball; when the fluid for compression is as a refrigerant: isobutane (R600a), the average speed V of the ball-and-socket joint mechanism section, and relation with the load F which acts on the ball-and-socket joint mechanism section at the time of a compression stroke is set as: $V \times F < 200N \cdot m/s$.